METALLURGICAL COKE MANUFACTURING METHOD BY BLENDING RAW BRIQUETTE

Hiroshi Joh and Shiro Ida

Technical Research Institute of Yawata Iron and Steel Works,
Yawata Iron and Steel Co., Ltd., Yawata Japan

1. Introduction

For making metallurgical coke high caking coal is generally blended with coal charge at high ratio.

Many an investigation; 1) have hitherto been made with an intention of saving high caking coal without degrading the quality of coke produced.

The methods attempted in Japan are as follows:-

(1) Coke breeze blending method. 2)
A small quantity of coke breeze, pulverized under about 0.012" is blended with the coal charge.

(2) Coalite blending method. 3)
Coalite pulverized under some 0.012" is blended with the coal charge.

(3) Bojun Tan method. 4)
Low grade coal with high volatile matter is swelled with oil in low temperature.

(1) and (2) were applied to practical operation for some period, but at present they have been stopped using for economical reasons.

There is no prospect of (3) being used in practical operation, notwithstanding it was an excellent investigation. Formerly, we intended to manufacture for many years metallurgical coke directly from low or non-caking coal with high volatile matter, using these coals as main raw material.

At the first stage it was clarified that coking property of these low grade coals was much improved by briquetting under comparatively low pressure (2845-3555 lb/in^2). Based on this fact, we could produce good metallurgical briquette coke (size: 1.65" x 1.65" x 1.18", strength: stability factor = 40-45 %, hardness factor = 72-74 %) by carbonizing raw briquette at high temperature, when the raw briquette was made from the mixture of low caking coal and non-caking coal reasonably blended as main raw material. The result was already published. 5). In this method the most important point is to keep the quantity of caking constituents of raw briquette within constant limits. It is impossible however to use the ordinary horizontal chamber oven, due to briquette coke (pillowshaped) of the product.

With the object of solving this problem we planned to carbonize the mixture of raw briquette and the coal charge in horizontal chamber oven, by blending raw briquette with the coal charge in coke plant. It is desirable in this case that the coal charge and raw briquette should melt each other during carbonization and good lump coke be produced as the result.

We should like to call this method "Metallurgical coke manufacturing method by blending raw briquette."

The present investigation is in the process of study, and not yet in the stage of discussing its economical value.

Next, mention is going to be made of the main paints of this method, as it seems to contain some technically interesting problems.

2. Characteristics of raw coal:

Table 1 shows the characteristics of the representative coals selected out of coals, that are used in a coke plant of Yawata Iron & Steel Works. Pitch in Table 1 is produced in the same plant, and used as binder in making raw briquette.

Table 1: Characteristicts of Raw Coals

Items / Raw Materials	Proximate Analysis A.	V.M.	F.C.	Fuel Ratio	S (%)	Button No.	Index of Quantity of Caking Constituents*6) (C.I.) (%)
American Coal with medium V.M.	5.02	23.11	71.87	3.11	0.68	8.0	90.5
American Coal with low V.M.	6.70	16.56	76.74	4.64	0.70	6.0	83.6
Kyushu Coal A (low caking coal)	6.89	40.56	52.55	1.30	0.61	3.5	80.1
Kyushu Coal B (low caking coal)	5.64	42.44	51.92	1.22	0.69	5.0	88.9
Pitch	0.50	65.60	33.90	0.52	0.42	-	88.8

In this case, moisture contents of base coal and briquette are severally 8 %, 4 %, and the size of the base coal is <1/4" as in an ordinary case. As seen in Table 2, the proper size of raw coals for briquette is <1/8".

Table 2: Characteristics of Base Coal and Raw Briquette

Items: Base Coal & Raw Briquette	Blending Ratio (%)	Screen Analysis of Raw Materials (%) > 1/8"	1/8"~1/16"	1/16"~0.035"	0.035"~0.023"	0.023"~0.012"	<0.012"	Proximate Analysis (%) A	V.M.	F.C.	S (%)	Button No.	Caking Index
Base Coal No.1	American Coal with medium V.M. 40 Kyushu Coal A 50 Kyushu Coal B 10	7.5	13.8	10.0	15.0	23.5	30.2	6.83	33.47	59.70	0.64	5.0	88.7
Base Coal No.2	American Coal with medium V.M. 60 Kyushu Coal A 30 Kyushu Coal B 10	5.0	12.5	6.5	16.0	21.0	39.0	6.68	30.32	63.00	0.65	6.0	89.0
Raw Briquette	Kyushu Coal A 72 Kyushu Coal B 10 American Coal with low V.M. 10 Pitch 8	0.3	9.9	9.0	10.6	18.6	51.6	6.72	38.22	55.06	0.61	3.5	88.4

The mixture of high caking coal and low caking coal, prepared so as to contain 40-60 % high caking coal in it is adopted as base coal, with which is blended raw briquette, and the final mixture is the coal charge. Table 2 shows blending ratios and characteristics of two kinds of base coal and raw briquette. And the size of raw briquette is 4/5" (length) x 4/5" (breadth) x 13/25" (height), this has been made specially smaller so that raw briquette may mix well with base coal.

* After 9g of dried coke breeze (48-65 mesh) is mixed with 1g. of dried coal (<65 mesh), the mixture is carbonized at 1742±77 °F. for 7 minutes. Coke produced is sorted out by screens of 35 mesh and 48 mesh. Supposing Ag is the quantity of coke over 35 mesh and Bg the quantity of coke, passed 35 mesh but not through 48 mesh screen, the caking index (C.I.) can be obtained by the following formula:

$$C.I. = \frac{A+B}{10} \times 100 \ (\%)$$

The briquette was manufactured in a pilot plant with capacity of 5 t/day.

3. Size of raw coals for briquette:

Blending ratios of briquette with the base coal (No.1 seen in Table 2) are as shown in Table 3. There are three different sizes of raw coals for briquette: <1/4", <1/8", and <1/16", excepting that size of pitch is always kept <1/4".

After briquette was blended at the rate of 30 % with the base, coke was manufactured in 500 lb. testing coke oven, and then crushing strength and tumbler strength of coke were examined. As shown in table 3, the proper size of raw coals for briquette is <1/8".

Table 3: Relation between Size of Raw Coal for Briquette and Strength of Coke, Blended Raw Briquette

Blending Ratio of Base Coal and Raw Briquette (%)		Size of Raw Coal for Briquette	Strength of Coke (%)		
			Crushing Strength**	Tumbler Strength	
Base Coal	Raw Briquette			Stability Factor	Hardness Factor
70	30	<1/4"	91.8	53.0	67.8
70	30	<1/8"	92.6	52.6	70.3
70	30	<1/16"	92.7	53.1	70.4

4. Bulk density of the mixture of base coal and briquette:

Investigating the bulk density on the mixture of base coal and briquette, it was clarified as shown in Chart 1 that the bulk density was developed with the increase of blending ratio of briquette with the base coal, and reached max. value, and then got down.

(Chart 1)

It is expected from the above-mentioned result that the quantity of coal charge per chamber increases by blending briquette with coal charge in practical coke oven.

5. Coke manufacture by a 500 lb. testing coke oven:

Coke manufacture was carried out in a 500 lb. testing coke oven, blending briquette with No.1 and No.2 base coal in various ratios under conditions that one charge is 660 lb., flue temp. of coke oven 2102-2156°F, and carbonization time 17 hrs.

The crushing strength of coke produced is promoted a little, compared with the use of base coal only as shown in Table 4 in case of blending briquette.

Besides, hardness factor increases and reactivity 7) becomes smaller.

From these facts, it is clear that the quality of coke is improved by blending briquette. Moreover, it is favourable that the size of coke has become smaller by this blending.

** JIS K. 2151-1957

Drum (φ59" x length 59") rotates in 15 r.p.m. for 2 min., putting 22 lb. of lump coke (>2") in it. Coke is sieved using various screens. Especially 19/32" index is important and the crushing strength is generally indicated by this index.

Generally speaking, the range of crushing strength for metallurgical coke is 91-93 %.

Table 4 : Manufacture of Coke, using 500 lb. Testing Coke Oven.

No.	Blending Ratio of Base Coal. (%)	Blending Ratio of Raw Briquette. (%)	Blending Ratio of Base Coal & Raw Briquette. (%)		Percentage of High Caking Coal in the Mixture of Base Coal and Raw Briquette. (%)	Characteristics of the Mixture (Base Coal + Raw Briquette)				Characteristics of Coke Produced.							
			Base Coal.	Raw Briquette		C.I. (%)	Proximate Analysis. (%) A.	V.M.	F.C.	Proximate Analysis. (%) A.	V.M.	F.C.	Crushing Strength. (%)	Tumbler Strength. (%) Stability Factor.	Hardness Factor.	***Reactivity (%)	Average Size of Coke. (in²)
(1)	No. 1	American Coal with low V.M. 10 Kyushu Coal B. 10 Kyushu Coal A. 72 Pitch. 8	100	0	40	88.7	6.83	33.47	59.70	9.40	0.81	89.79	92.7	57.4	67.6	44.0	2.81
(2)	American Coal with		50	50	25	88.5	6.80	37.27	55.93	9.60	0.72	89.68	92.7	53.1	70.9	33.6	2.80
(3)	medium V.M. 40		60	40	28	88.5	6.79	36.69	56.52	10.10	0.85	89.05	92.8	51.9	68.8	38.9	2.80
(4)	Kyushu Coal B. 10		70	30	31	88.6	6.49	35.69	57.82	9.60	0.56	89.84	93.3	52.1	70.3	32.6	2.67
(5)	Kyushu Coal A. 50		80	20	34	88.5	6.47	34.91	58.62	9.50	0.71	89.79	93.2	52.2	69.0	38.5	2.68
(6)			90	10	37	88.5	6.78	34.76	58.46	9.50	0.81	89.69	93.3	54.7	69.4	40.0	2.68
(7)			95	5	39	88.6	6.80	34.66	58.54	9.40	0.91	89.69	92.7	55.7	67.5	42.8	2.71
(8)	No. 2	American Coal with low V.M. 60 Kyushu Coal B. Kyushu Coal A. Pitch.	100	0	60	88.3	6.48	29.96	63.56	8.54	0.58	90.88	93.3	56.8	68.1	38.6	2.80
(9)	American Coal with		90	10	55	88.9	6.60	30.67	62.73	8.50	0.68	90.82	93.3	58.2	68.8	38.0	2.79
(10)	medium V.M. 60		70	30	45	88.8	6.34	32.87	60.74	8.71	0.78	90.51	93.8	56.0	71.2	35.8	2.71
(11)	Kyushu Coal A. 10 Kyushu Coal B. 30		50	50	35	88.6	6.25	34.90	58.85	8.92	0.81	90.27	92.6	51.6	70.5	40.2	2.80
(12)	High Caking Coal. 51.5 Kyushu Coal 48.5 (Blending Ratio of Coal Charge, Yawata Iron & Steel Works, in March, 1958.)		100	0	51.5	90.1	8.65	31.29	60.08	11.57	1.34	87.09	93.0	55.1	66.1	44.5	3.08

*** Reactivity is calculated from the composition of CO_2 and CO of gas produced.

As a natural result the blending ratio of high caking coal in the total coal charge has decreased, in proportion to the augmentation of briquette blended. For example, the using rate of high caking coal has been 30 % as shown in the No.(4) in which briquette was blended at a rate of 30 %.

It is recognized from the results that high caking coal is able to be saved to some extent. Moreover, the prototype of briquette was not observed in lump coke on the occasion of blending briquette under 30 %, due to the perfect melting of briquette and base coal during carbonization.

6. Swelling pressure test:

Swelling pressure test was examined for the purpose of comparing the result on the two kinds of samples i.e. mixture, blended briquette with base coal at the rate of 30 % and coal charge (blending ratio: high caking coal 50 %, Kyushu coal 50 %, Yawata Iron & Steel Works in August, 1958).

Swelling pressure was measured in Kopper's movable coke oven 8) under conditions that flue temp. is 2192°F, carbonization time 16 hrs., and one charge 660 lb. Swelling pressure of mixture, blended briquette was a little smaller than in the case of ordinary coal charge, as seen in Chart 2.

(Chart 2)

7. Other tests:

Firstly, quality segregation of coke in a chamber of coke oven was studied on the mixture (blending ratio: base coal 70 %, briquette 30 %), in the case of coke making by blending briquette with base coal. It was explained as the result that there was no particular fear of quality segrigation of coke, by mixing base coal and briquette.

Secondly, we tested the by-product on the mixture, in comparison with the case of the base coal only and it was ascertained that yield of tar, light oil in gas and gas has been improved slightly in the case of blending briquette, excepting that the yield of ammonium sulfate decreases.

8. Summary:

Several experiments were carried out to establish the manufacturing process of metallurgical coke, in which while the blending ratio of the high caking coal with the total charge is smaller than in ordinary case, the quality of coke obtained should be not inferior to the ordinary blast furnace coke. For this purpose, the raw briquettes made from low caking coal as main raw coal were blended with the base coal which was almost the same in blending ratio of high caking coal as the coal charge in ordinary coke plant.

The following results were obtained.

(1) It was ascertained that the proper size of raw coals for briquette to be blended with the base coal was under 1/8". The blending ratios of the base coal and the briquette are as follows:

Base coal (high caking 40 %)	
Medium volatile American coal	40 %
Kyushu coal A	50 %
" B	10 %
Briquette (high caking coal 10 %)	
Kyushu coal A	72 %
" B	10 %
Low volatile American coal	10 %
Pitch (as binder)	8 %

(2) The bulk density of coal charge (base coal + briquette) increased, by blending the briquette with the base coal.
(3) The qualities of coke produced in 500 lb. test coke oven by carbonizing the mixture, blended briquettes at the rate of 5-50 % with the base coal, were generally improved by blending briquette in other words the crushing strength and hardness factor were increased and, moreover, the mean size and reactivity decreased. Thus, it is possible for us to foresee that the saving of high caking coal can be carried out by blending briquette with the base coal.
(4) In the case of blending briquette with the base coal, it was considered that the upper limit of the blending ratio of the briquette was about 30 %, from the observation of lump coke quality and the security of pushing of coke from a chamber in coke oven
(5) It was attested by the experiment by 500 lb. Kopper's movable wall oven that, when the briquette was blended with the base coal at the rate of 30 %, the expansion pressure during carbonization were in the limits of safety.
(6) The segregation of coke quality has no trouble in the blending of briquette under above mentioned limits and the yield of by-product is rather favourable by blending briquette with the base coal.

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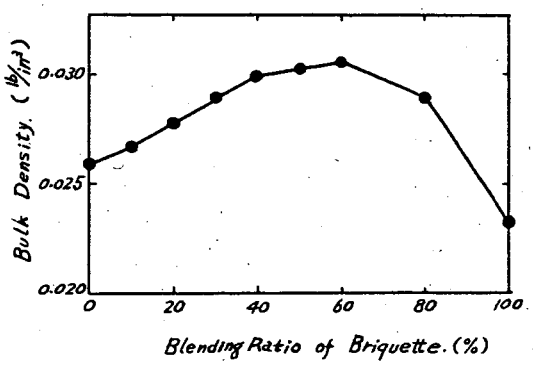

Chart 1 : Relation of Bulk Density and Blending Ratio of Briquette.

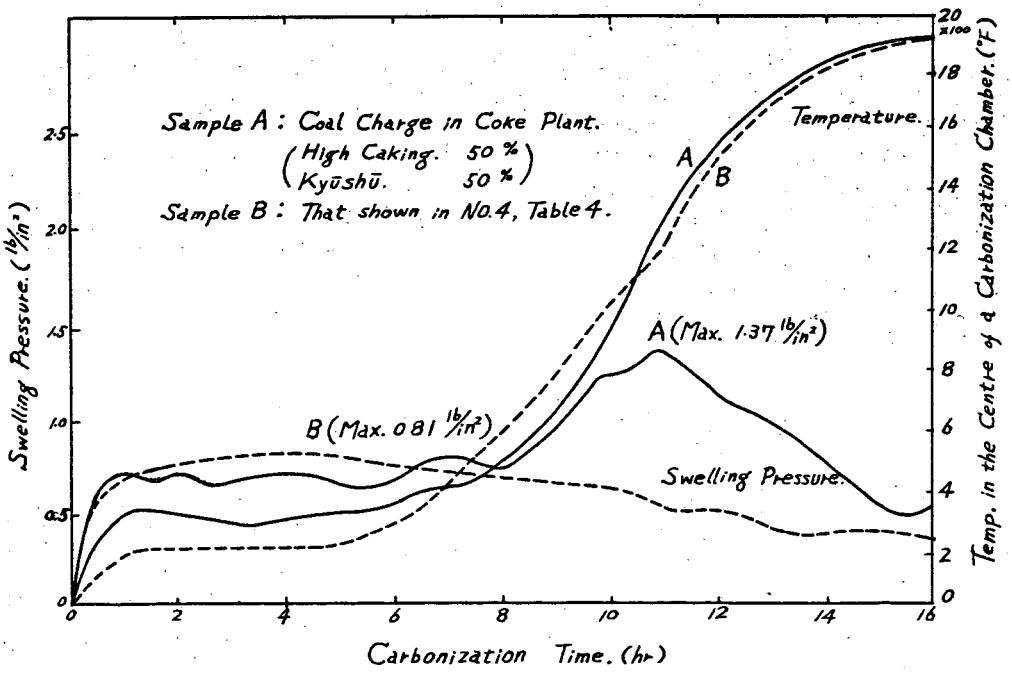

Chart 2 : Comparison of Swelling Pressure.